The Nationwide Differential Global Positioning System's Role With Hurricane Katrina's Recovery

Abstract

The Nationwide Differential Global Positioning System (NDGPS) is an augmentation system to GPS, providing real time corrections and integrity monitoring to validate GPS signal integrity and improve position accuracy. Originally set up for CG Aids to Navigation (AtoN) positioning, usage has grown to include other federal agencies, local governments and private industry. Uses during Hurricane Katrina's recovery efforts highlighted the importance of NDGPS as extremely valuable, enabling technology, supporting our transportation infrastructure and commerce.

Background

NDGPS briefly explained: NDGPS is a GPS augmentation system, managed by the Department of Transportation and operated by the U.S. Coast Guard. NDGPS continuously broadcasts corrections to the local GPS signal to improve positioning accuracy to within ten meters, as may be needed for many surveying or navigation activities. NDGPS also provides a continuous integrity monitoring function of GPS, and warns users to not use an errant GPS signal which could provide false positioning information. Because of the position accuracy and continuous integrity monitoring, DGPS meets the Federal Radionavigation Plan criteria for harbor and approach navigation.

The current system consists of 85 transmitting sites located throughout the United States including Puerto Rico, Alaska, and Hawaii. All sites are unmanned and remotely controlled from two Control Stations located in Alexandria, VA and Petaluma, CA. Long term goals are to provide redundant signal coverage throughout the conterminous United States. The current signal coverage is shown in figure 1.

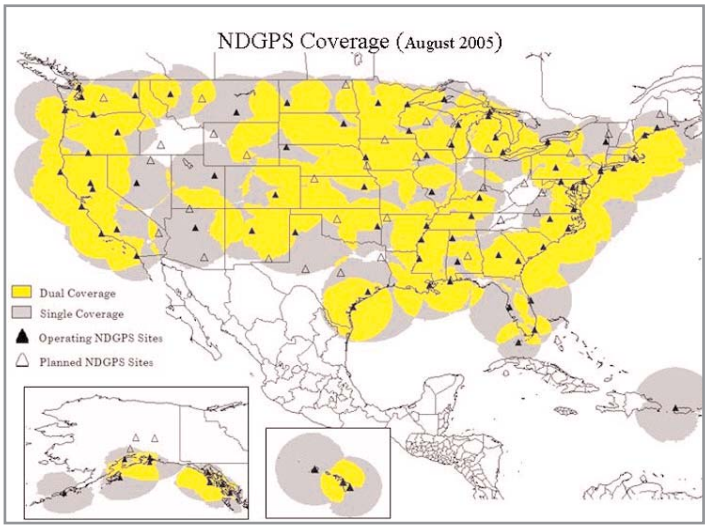

Figure 1:

(a) Readiness

The Coast Guard took numerous measures to obtain optimal performance of NDGPS sites in the Gulf and lower Mississippi areas prior to Hurricane Katrina. Existing equipment deficiencies were corrected, communication lines used for sending and receiving information were checked, generators at equipped sites were refueled and each site's spare parts kit was verified and restocked as needed. The Army Corps of Engineers pre-staged a portable generator at Vicksburg in anticipation of a prolonged loss of primary power. All sites in the Gulf regions were operational as pictured in figure 2.

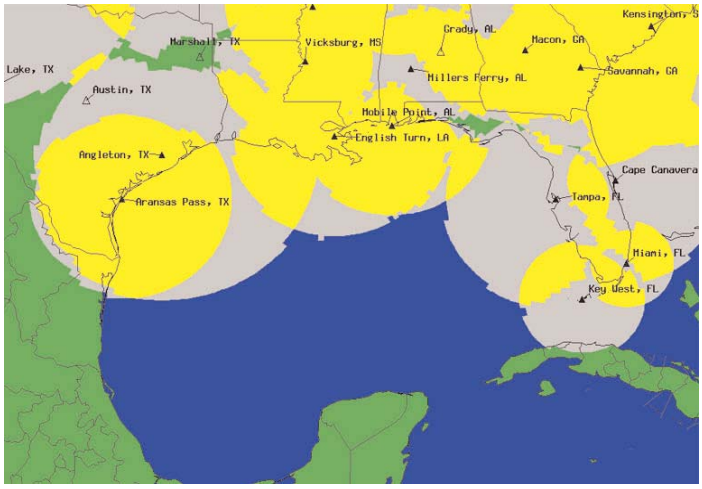

Figure 2:

The NDGPS sites also contribute to hurricane readiness measures of the National Oceanic and Atmospheric Administration (NOAA). NOAA's National Weather Service uses site resources to gather information to improve weather forecasting and position accuracy. The coastal sites, referred to as maritime sites, are equipped with GPS Surface Observing System (GSOS) equipment, used to collect weather data and precipital water vapor to enhance weather predictions. Additionally, the National Geodetic Survey (NGS) also affiliated with NOAA, uses one of the site's two reference stations to collect GPS raw data. These data are corrected to centimeter accuracy and used for precise positioning and surveying through post processing survey data. This system is called Continuously Operating Reference Stations (CORS) and is incorporated at all NDGPS sites.

(b) Response

In response to Hurricane Katrina, the Coast Guard closed the following Ports in the Gulf Coast Region: The Port of Mobile, AL, Port of Pascagoula, MS, Port of Gulfport, MS, Port of Bayo La Batre, Port of Biloxi, MS, Gulf Intercostals Waterway, Port of South Louisiana, Port of New Orleans, Port of St Bernard, Port Plaquemines and the Port of Greater Baton Rouge. These ports, which comprise a significant percentage of all U. S. shipping capacity, and handle approximately 60% of U. S. grain and exports, remained closed during and after Hurricane Katrina.[1]

The Coast Guard Navigation Center, which operates the NDGPS system, continuously monitored the DGPS transmitting sites status, and kept local Coast Guard commands and other users informed of signal availability. In addition, Coast Guard Electronic Support Units assisted in ensuring that storm damage at critical transmitting sites was quickly mitigated to maximize the NDGPS signal availability.

Recovery

Within hours after Hurricane Katrina, Port Authorities, the USCG, and personnel from other government agencies began work around the clock, first to assist in search and rescue efforts, next to assess the damage to marine facilities, harbors, and waterways, and finally, to restore infrastructure.

Many federal agencies and other organizations involved in the recovery of the affected waterways and in other related recovery efforts made use of the NDGPS signal. These NDGPS supported efforts are described below.

U. S. Coast Guard (USCG) - The Coast Guard's main mission in infrastructure recovery is re-positioning Aids to Navigation (AtoN), keeping the waterways open for safe navigation. The NDGPS service is vital to crews carrying out AtoN missions. This service allows the positioning accuracy required to carry out the mission in an efficient and timely manner.

The Coast Guard restored nearly 1800 Aids to Navigation that were displaced by Hurricane Katrina. They deployed 14 vessels equipped with NDGPS receivers as part of their Electronic Charting and Navigation Systems. This system allowed the efficient and extremely precise positioning of buoys and fixed Aids to Navigation. In addition to the AtoN mission, Coast Guard vessels carrying NDGPS receivers carried out the following missions:

- Evacuation Operations
- Search and Rescue
- Vessel Escort/Prior to Channel Restoration
- Document Recovery
- Environmental Response
- Personnel Transport
- Hydrographic Surveying
- Obstruction identifying and clearing

U.S. Army Corps of Engineers (USACE) - NDGPS was used for hydrographic surveying by the USACE to determine underwater topography. Hydrographic surveying was used in conjunction with dredging operations to check the depth of the shipping channels and to clear obstructions and debris. According to the USACE personnel, if NDGPS were not available, the Corps would have to revert to slower, less efficent technologies.

The USACE responded by deploying six contract survey boats equipped with NDGPS equipment immediately after the disaster to conduct Hydrographic Surveying. The USACE carried out missions critical to the viability of over 38 ports and waterways in the Mobile and New Orleans area. Essential ports and waterways were able to re-open after the USACE completed surveying and dredging to identify precise locations of navigational hazards and determine the depth of waterways. As a result, agencies were able to carry out life saving missions such as providing critical supplies in a timely manner.
(Johnny D. Barnes, personal communication, October 31, 2005 and Nelson R. Sanchez, personal communication, November 3, 2005)

National Park Service (NPS) - The NPS crews arrived the first week after Hurricane Katrina carrying NDGPS units to survey the Barrier Island Shorelines along the Gulf Coast. Crews used Garmin 5 model WAAS units and Trimble NDGPS Receivers in their efforts to map the locations of unsafe areas such as areas with hazardous materials. They also mapped the locations of safe usable roads and trails that could be utilized for safe passage.
(Andy Steel, personal communication, November 4, 2005)

U. S. Department of Agriculture (USDA) - The USDA has over 6000 NDGPS units available for use including backpacks and mounted versions. These units were used in conjunction with charts and satellite imagery while carrying out the following missions:

- Locating disposal sites for animal carcasses
- Mapping area with blocked drainage for future clearing

(Mike Thrasher, personal communication, November 4, 2005)

National Oceanic and Atmospheric Administration (NOAA) - Throughout the Hurricane, NOAA was able to collect surface observation information from equipment collocated with NDGPS sites used in Weather Forecasting. Additionally, NOAA assisted with hydrographic and aerial surveying. Without NDGPS their surveys would have been delayed at least one week to set up temporary short range reference stations.
(Seth I. Gutman, personal communication, November 2, 2005)

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[1] Adams, C., and K. G. Hall.(2005, September 8) *Closed New Orleans Port Creating Problems.* Retrieved September 9, 2005, from http://www.miami.com/mld/miamiherald/12585180.htm.

Commercial Pilots - Pilots from Crescent City Pilot's Association used Raven Invicta 210 model wireless NDGPS receiver units while carrying out the following missions:

- Docking vessels
- Vessel escort including the Navy vessel, USNS Iwo Jima

Pilots from the Lake Charles area were able to continue operations due to NDGPS signal availability. Lake Charles pilots have an off bar transit of 36 miles, the longest open water pilotage in the country. During Hurricane Katrina, all navigational aids in the area were destroyed. Additionally, environmental conditions, such as silt clouded water, made it difficult for pilots to 'read' the waterways. As such, electronic navigation systems were critical to navigation, and the accuracy provided by the NDGPS enabled precision pilotage of large vessels through the affected waterways.
(Douglass Grubbs, personal communication, November 3, 2005 and January 8, 2006)

Results

Within two weeks after Hurricane Katrina devastated the Gulf region, major ports were re-opened. This allowed commerce to flow in and out of harbors along the Gulf coast and up and down the Mississippi River. The reopening of waterways immediately eased suffering of regional residents, mitigated further infrastructure damages and contributed to the restarting of refinery operations and grain exports.

NDGPS contributed directly to the above noted results through the expedited opening of key ports and waterways, enabling the safe navigation of critical Search and Rescue and supply platforms, and facilitating the restoration of commercial maritime traffic. The Coast Guard restored nearly 1800 Aids to Navigation using NDGPS and the Army Corp of Engineers surveyed and dredged accordingly some 38 critical waterways. Commercial pilots used NDGPS for pilotage duties when "reading the river" was no longer possible, bringing in huge re-supply and relief ships. The USDA used NDGPS to determine areas for the safe removal of decaying debris and for the geodetic marking of flooded areas for flood relief efforts. NDGPS sites and positioning information were critical to NOAA in their weather forecasting, in an area that all relief and restoration efforts hinged on precipitation amounts.

Conclusions and Recommendations

The NDGPS broadcast provides a critical service to the navigational community and contributes to the safe transport of commerce which is vital to the economy. With minor exceptions, the broadcast remained available to critical areas affected by Hurricane Katrina. However, many problems in keeping the NDGPS signal available during the recovery period were faced. The success in solving these problems to keep the signal available can be attributed to the extraordinary efforts made by Coast Guard support teams from Electronic Support Unit New Orleans, Communications Station New Orleans, Electronic Support Unit Detachment Mobile, Electronics Support Unit Detachment New Orleans, and the USACE from Vicksburg, MS and Millers Ferry, AL. The Coast Guard Navigation Center has documented several system vulnerabilities and is seeking resources to address these in order to further improve reliability of this critical infrastructure. Without NDGPS availability in the wake of Katrina the degree of despair, suffering and economical plight for the long term would have been significantly increased.